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Can Biofuels be an Engine for Growth in Small Developing Economies – The Case of Paraguay

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1. Introduction

This analysis examines the feasibility of setting up a biofuels sector in Paraguay. As a small agriculturally-based country, Paraguay can serve as an interesting test case for the feasibility of creating ethanol in other small developing countries, such as those in Central America. Our analysis is inspired by previous work on the remarkable success of Brazil's ethanol industry (Hira, 2009). More than 80% of Brazil's cars can run on a spectrum of gas and alcohol blends based on local sugarcane supply and processing. Ethanol reduces dependency on politically volatile and expensive petroleum imports. The International Energy Administration, along with other recognized international energy institutions, states that while demand will continue to increase over the long-term, prospects for supply meeting that demand "are extremely uncertain (IEA, 2008, 3)." A viable biofuels sector could help Paraguay to improve energy security and reliability, spur economic growth and reduce external dependence, improve employment and rural development, possibly create a new export industry, and reduce greenhouse gas emissions. We focus here on sugarcane ethanol. Sugarcane ethanol is the most attractive option, the only feedstock currently providing an economically feasible substitute at an estimated oil price of $70/barrel, and is more environmentally friendly than other feedstocks as waste is burned for electricity cogeneration. Sugarcane ethanol also produces less carbon emissions than petroleum. As a recent report states, there is no explicit policy at present for biofuels in Paraguay (IICA, 2007, 54). This report is based on secondary analysis and field research conducted during July 2009. We note here the severe constraints on primary data, requiring a more qualitatively-oriented approach.

We organize our analysis around an examination of the following factors: **agricultural, economic, and governance**. The problem of sustainability must be addressed by any plan along with economic/financial feasibility, however, we believe that this question is adequately answered in a number of analyses that demonstrate that sugarcane ethanol, if conducted with safeguards, is a net reducer of carbon emissions (Goldemberg, 2007).

2. The Paraguayan context: pressures for economic change

2.1 Political context

Paraguay's geographic isolation and lack of mineral wealth left it in the periphery of Spanish colonialism. Paraguay also has a history of military dictatorship, with some

exceptional periods of stability around central leaders marred by long periods of instability. Modern Paraguayan history begins with the ascension of Alfredo Stroessner through military coup in 1954. Stroessner ruled the country until his overthrow by coup in 1989. While dictatorial, he also presided over rapid economic growth in the 1970s led by increases in agricultural production and the construction of the large binational dam projects, Itaipú and Yacyretá. Stroessner used the Colorado Party and the military as the key institutions for Paraguayan political power. Economic decline during the 1980s, including the end of Itaipú construction; drops in agricultural export prices; and ongoing concerns about corruption fed growing political opposition led by the Church and eroded support for Stroessner. There was also concern about the development of large agro-businesses and the purchase of large swathes of land by foreign, mainly Brazilian, interests (Lewis, 1991, 264).

These issues, Stroessner's age (72), and uncertainty about his successor, precipitated his top assistant, General Andrés Rodríguez, to overthrow him and begin the present phase of democratic rule. After several elections and other sidesteps, Paraguay's nascent democracy seems to be maturing at a rapid pace. The current President, Lugo, is a social reformer who is the first opposition (to the Colorados) candidate to peacefully win election in Paraguay's history. Lugo's coalition government is a fragile one, reflecting difficulties in developing a strong economic vision and policy for the country during a period of transition. For democracy to survive, economic conditions have to be ripe for the inclusion of more of the population in economic activities. Lugo's government has been chastened by widespread land protests, reflecting the tense situation of inequality in the country.

2.2 Economy

Economic growth in recent years, however, has tailed off considerably, including negative growth rates in 2001-2003. The economy has become more liberalized under the new governments, with openness (% of exports and imports/GDP) increasing from averaging 27% in 1961-70 to 82% from 1991-2000! Curiously, the government share of the GDP has also slightly increased, moving from 12 to 17% over the same period (Hira calcs from PWT). The heavy reliance on the public sector, going back to the Stroessner days, is accompanied by a heavy external debt. External debt as a percentage of gross national income increased from an average of 26% in 1960-70 to 38% in 2001-7 (Hira calcs from WDI). The current economic situation shows other causes for alarm. Unemployment has shot up, from an average of 4.1% in 1971-80 to 8.7% between 2001-7. The new democratic governments have not been able to attract significant amounts of foreign direct investment, the expected engine of growth after liberalization, which increased only slightly from an average of 1% in 1960-70 to 3% from 2001-7 (Hira calcs from WDI).

The problem is particularly pressing for the long-term. While Paraguay has a population of just 6.2 million, the growth rate by decade has remained high since the end of World War II, reaching 28% from 1991-2000 (Hira calcs from PWT). This means considerable pressure for employment is occurring. Indeed, Paraguay has one of the youngest populations in the region, with 26% of the population under the age of 10, leading to an incipient bulge in the work force (IDB 2008, 5).

Paraguay has a major blessing in terms of the steady revenue and cheap electricity provided to it through the Itaipú and Yacryretá binational dams. Yet, there are serious impediments to economic growth. There is a low level of overall competitiveness, related to corruption, lack of finance, weak export diversification, income distribution concentration, and a low

level of human capital. Infrastructure, including roads, are poor. Only 35% of the population has more than a primary education (IDB 2008, 7), though university enrolment more than doubled from 1990 (25,989) to 2000 (59,836). Yet funds for research and development and systems such as accreditation and evaluating are sorely lacking (IDB 2008, 16-18).

According to the Vice President's Office (2009), poverty increased in Paraguay from 30% of the population in 1995 to 35.6% in 2007. Extreme poverty increased from 6.8 to 27.4% during the same period. These are indicators that macroeconomic stability and agricultural production improvements have not reached significant levels of the population.

These facts add up to a desperate need for new sources of income and employment. Yet, it is not realistic to think that new manufacturing industries are likely to arise given the limited population centers and the isolation of the country, as well as the inability to compete with lower wage production in Asia. Also, the idea of developing advanced services, financial or technological, does not seem plausible in the short- to medium-term given major problems with educational systems and political and institutional weaknesses. While such industries should be encouraged, they are unlikely to create the numbers of jobs at lower levels of education needed by the growing workforce. This leaves agriculture, Paraguay's natural comparative advantage.

3. Agriculture in Paraguay

The Paraguayan economy is organized primarily around agricultural production. The agricultural sector accounts for 30% of GDP, 45% of jobs, and 80% of exports. Therefore world prices on principal goods such as soy and cotton have great impact upon Paraguay's well-being (IDB, 2008, 6). Colonization of the Eastern frontier during the 1970s led to major expansion of export crops. Cotton increased from 1.1% of total exports in 1960 to 44% in 1985; soy went from negligible to over 16% in 1981. During the same period, more traditional products cattle and quebracho (source of timber and tannin) declined (IDB, 2004). Forty three percent of the population lives in rural areas. Ninety-nine percent of the population lives in the Eastern half of the country. According to a USAID report, in this Eastern portion, there are 16 million hectares, of which 9 (56%) are dedicated to agriculture and livestock. Agriculture occupies 2.8 million hectares, including 1.9 for mechanized agriculture and 0.9 that is based on family plots. Livestock occupies 5.2 million hectares and fallow land another 1 million. In the Eastern region, 84.2% of all farms and ranches have less than 20 hectares, with family incomes of less than $250, indicating extreme poverty. Those with between 20 and 200 hectares cover another 13.9% of all farms and ranches, and have annual incomes of less than $2,500/year, indicating economic efficiency. As a result of this inequitable distribution, Paraguay has experienced peasant movements throughout its history to redistribute land. These are a reflection of the fact that, particularly after the end of dam construction, there are few other industries to generate employment for campesinos (USAID, 2004). Property rights are poorly defined and there are few families with clear land title (IDB, 2008, 22).

While food exports have been increasing, there are signs of a continuing long-term migration to cities, which goes hand-in-hand with the aforementioned issues around agricultural concentration and unemployment, as noted in Fig. 1.

Food exports and rural population, 1960-2007

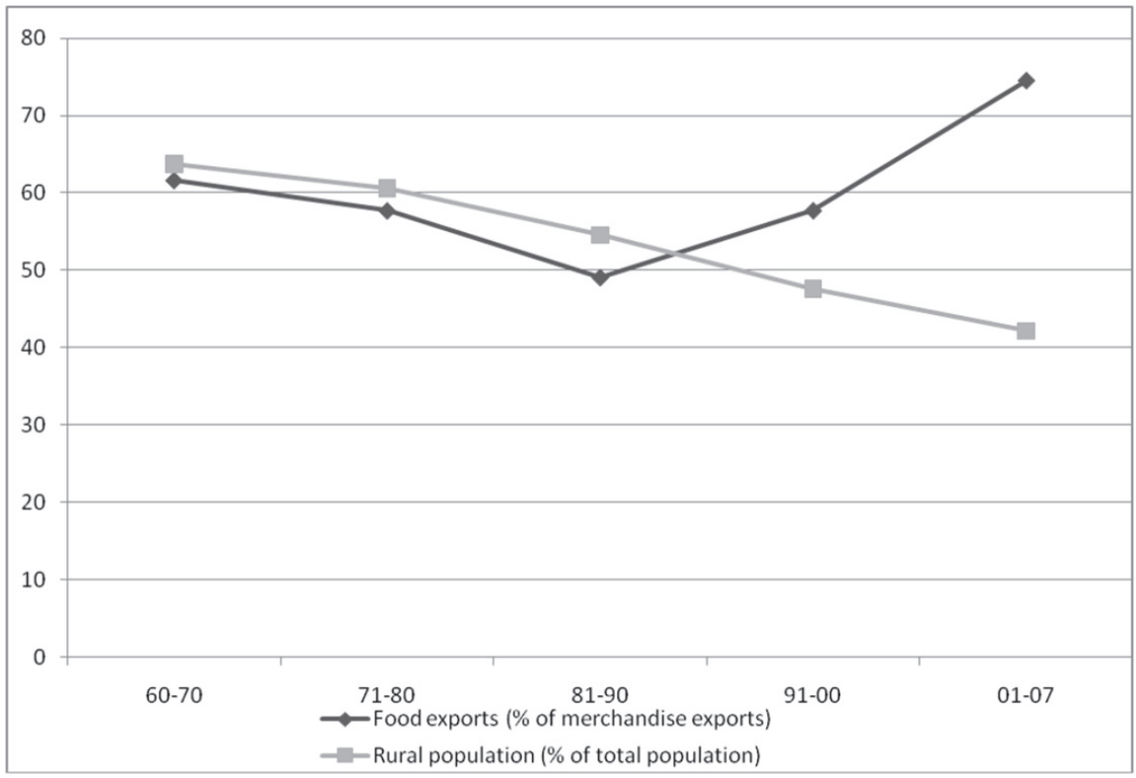

Fig. 1. Source: WDI

If agricultural productivity increases were accompanying the large scale urban migration, one could presume net positive benefits. Yet, while exports are increasing, as seen in Fig. 2 there are indicators that productivity appears to be fairly stagnant, indicating absolute production is increasing, but general productivity is not. It is likely that agricultural production is increasing through agglomeration and increasing use of land (rather than productivity).

4. Why ethanol might make sense for Paraguay

The International Energy Association/OECD (IEA, 2007a) projects that world energy demand will grow by 50% between 2005 and 2030. Developing countries, primarily China and India, will account for 74% of that increase. Fossil fuels- oil, coal, and natural gas- currently provide more than 80% of the world's energy supply (Henimo and Junginger 2009). Like most analysts, the IEA is skeptical that increases in demand can be met by traditional fossil fuel sources alone. Moreover, with increasing concerns over climate change, the most likely short-term alternative fuel, coal, is viewed with trepidation. Furthermore, the greatest increase is likely to be in transportation, where coal cannot be used easily as a fuel, at least with current technologies. These concerns have sparked a surge in interest in renewable fuels. As of 2005, combustible renewables and waste made up just 10% of the world's energy supply, with hydro accounting for another 2.2% (IEA 2007b).

Indicators of agricultural productivity, 1960-2007

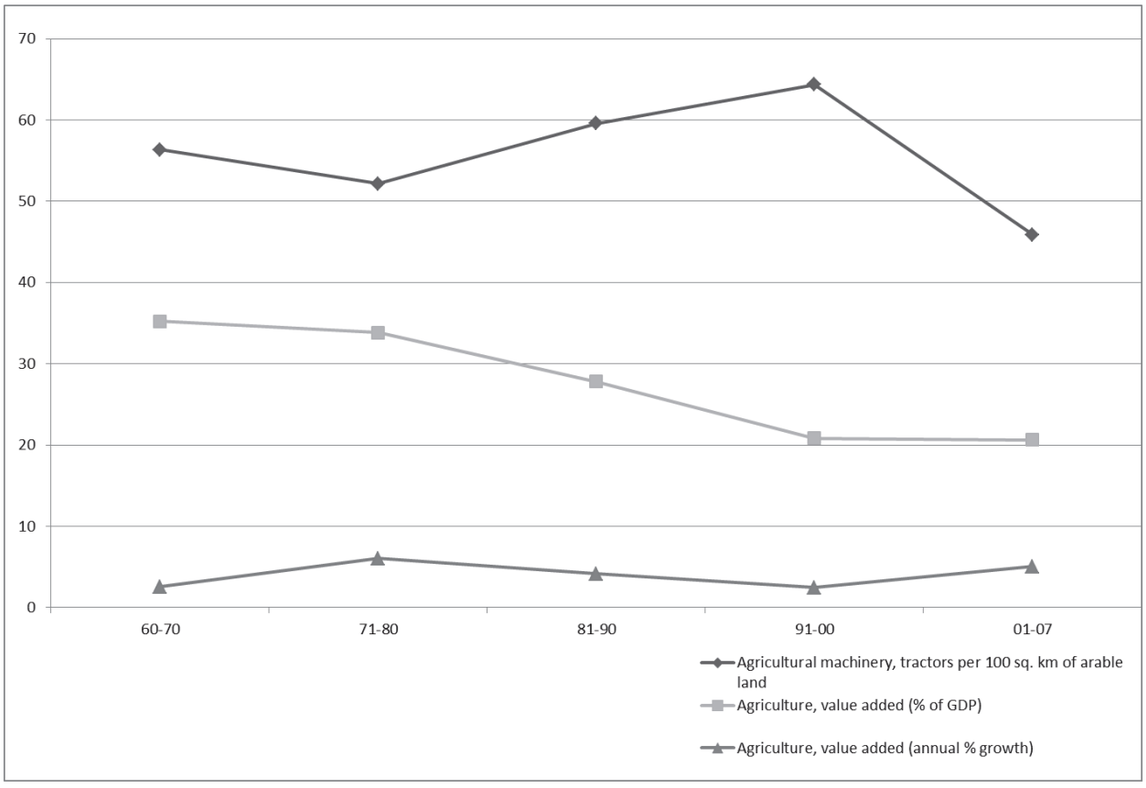

Fig. 2. Source: WDI

4.1 Sugarcane ethanol can serve as a petroleum substitute

Ethanol is a highly controversial subject, with sceptical media such as Time magazine (March 27th, 2008) calling it "The Clean Energy Scam," meaning that the subsidies given to ethanol were not worth the energy it produced. A flurry of negative press, particularly around the 2008-9 period, linked biofuels subsidies to then skyrocketing world food prices and created a food for fuels debate that continues on even as world food prices have abated. Increases in food prices are more closely tied to impressive economic growth in China and India during the last decade, which increased demand and changed diets, as well as increases in petroleum prices, which once receding in 2009 have brought down food prices with them (Hira, forthcoming a). Therefore, the choice of feedstocks, and the economic trade-offs each entails, is a key part of assessing the viability of the biofuel in question.

While we can not provide an exhaustive background, the feasibility of this study depends foremost on discussing 2 aspects of this debate. First, we need to examine whether the net benefits of ethanol allow it to be a feasible substitute for petroleum, and secondly we need to see whether sugarcane is the appropriate feedstock for making ethanol.

As with other markets, there is no "definitive" way to identify the breakeven point for sugarcane ethanol vs. petroleum. Markets are intertwined, so that when the price of petroleum goes up, it will necessarily increase the costs for producing sugarcane. Similarly, the demand for sugar in food will evidently compete with its use for ethanol. Moreover, every situation will lead to different costs for production of both ethanol and linked and

substitute products- it will depend on the land, the inputs, the macroeconomic conditions, the wage rates, even the weather. The opportunity cost of producing ethanol is estimated at 1.67 X the price of producing sugar (BNDES and CGEE, 2008, 52). However, these rough calculations must be taken with caution given the major distortions to the sugar market such as quotas in the US market (Hira,forthcoming b).

However, current global production does not reflect cost efficiency; sugarcane is by far the cheapest source of biofuel. The differences in feedstock efficiency are estimated to be quite substantial. Rapeseed produces 100 gallons of biofuel per acre; corn 400; and sugarcane 660 (Coyle 2008). Another estimate puts the costs at: $835/ton of fuel in Europe based on vegetable oils; $546/ton in the US based on corn; and just $387/ton in Brazil based on sugarcane (Prakash 2007). The IEA (2007) estimates that sugarcane ethanol costs the equivalent of $.25-.35/liter of gasoline equivalent (lge), and so is competitive with gasoline at $40 per barrel oil prices. Corn in the US and sugar beets in the EU are estimated to cost $.60-.80/liter, or 3X as much. Moreover, the same report notes that sugarcane fuel leads to up to a 90% reduction in CO2 emissions compared with gasoline while corn ethanol leads to just a 15-25% reduction. In sum, there is a consensus that corn as a feedstock is considerably less efficient than other feedstocks such as palm oil and sugar (Delucchi 2005; De Oliveira 2006; Farrell 2006; Larson 2005). Some studies estimate that corn uses 29% more fossil fuels than the energy it produces, and that vast expansions in cropland and/or productivity would be needed in order to satisfy just a portion of US vehicle needs for fuel (Lokey 2007).

Brazil's example leads the world in terms of continuing reduction of production costs of ethanol (van den Wall Bake, Junginger, Faaij, Poot, Walter, 2009; Goldemberg, Coelho, Nastari, and Lucon, 2004); of providing *flexibility* in markets to adjust to price swings of sugar and petroleum; and of reducing labour and environmental costs by phasing out manual harvesting (Hira and de Oliveira, 2009). Fully 80% of cars in Brazil are now flex fuel, able to run on a spectrum of alcohol and gas blends. Brazil's ethanol industry has created 1 million jobs, and significantly reduced reliance on petroleum imports. Moreover, Brazil has perfected cogeneration using bagasse (cane waste) so that mills are now exporting power to the grid (Mathews, 2006). Brazilian sugar mills' surplus energy generation is expected to continue to accelerate as generation efficiency improves. The cogeneration aspect differentiates sugarcane efficiency from sugar beets and other feedstocks as nothing is wasted (BNDES and CGEE, 2008, 77, 85; Worldwatch Institute, 2007, 166-67). Recent studies also support the claim that ethanol creates lower emissions than gasoline, with significant reductions in CO and hydrocarbons, but slightly higher emissions of aldehydes (BNDES and CGEE, 2008, 47-8).

A number of studies put the breakeven point for Brazilian sugarcane ethanol at US $70/barrel. A 2006 study of cost comparisons suggested that Brazilian ethanol was being produced at $0.42-45/litre and was therefore competitive with the then world price of gasoline at $0.55/litre. It cautioned though that transportation costs would add significantly in the case of exports (S&T, 2006, 21). A comprehensive life cycle analysis of sugarcane bioethanol vs. gasoline concluded that, at crude oil prices in 2005 (about $50/barrel), it was at the breakeven point (Luo, van der Voet, Huppes, 2009). Prices have declined from a high in 2008 of around $91 to around $70/barrel now. We should also keep in mind that the petroleum industry has been receiving billions of dollars in subsidies including largely publicly funded transportation infrastructure over the last century.

4.2 Paraguayan dependence on oil imports

There are several reasons why expanding ethanol production might make sense in Paraguay. The first is that Paraguay is 100% dependent upon imports of foreign oil. World energy consumption is projected to increase by 50% from 2005 to 2030, fuelled by economic growth in China and India, particularly as auto purchases proliferate. Oil prices are expected to continue on a high trajectory over the period. Meanwhile, there are no signs that major new finds will allow supply to keep pace (EIA, 2008). The International Energy Association agrees with these assessments, and notes that oil supplies might peak sometime after 2030 (IEA, 2008, 91).

4.3 Potential for sugarcane production

Paraguay has the possibility of significantly increasing its production of sugarcane; climactic and soil conditions are propitious. The FAO land database suggests that just 10% of arable land is in use in Paraguay. Paraguay in the 1980s expanded the use of ethanol, but this only affected 1/6 of the 40,000 vehicles there (Hanratty and Meditz,1988, 147). Such a move would allow Paraguay to move away from its traditional concentration in meat and its new and growing dependency on soy exports, along with a high degree of vulnerability to world price swings in those products. Moreover, unlike soy, which has been linked to large scale plantations leading to deforestation, sugarcane could be developed from transforming currently under-utilized smallholder subsistence plots.

Paraguay top exports 2006

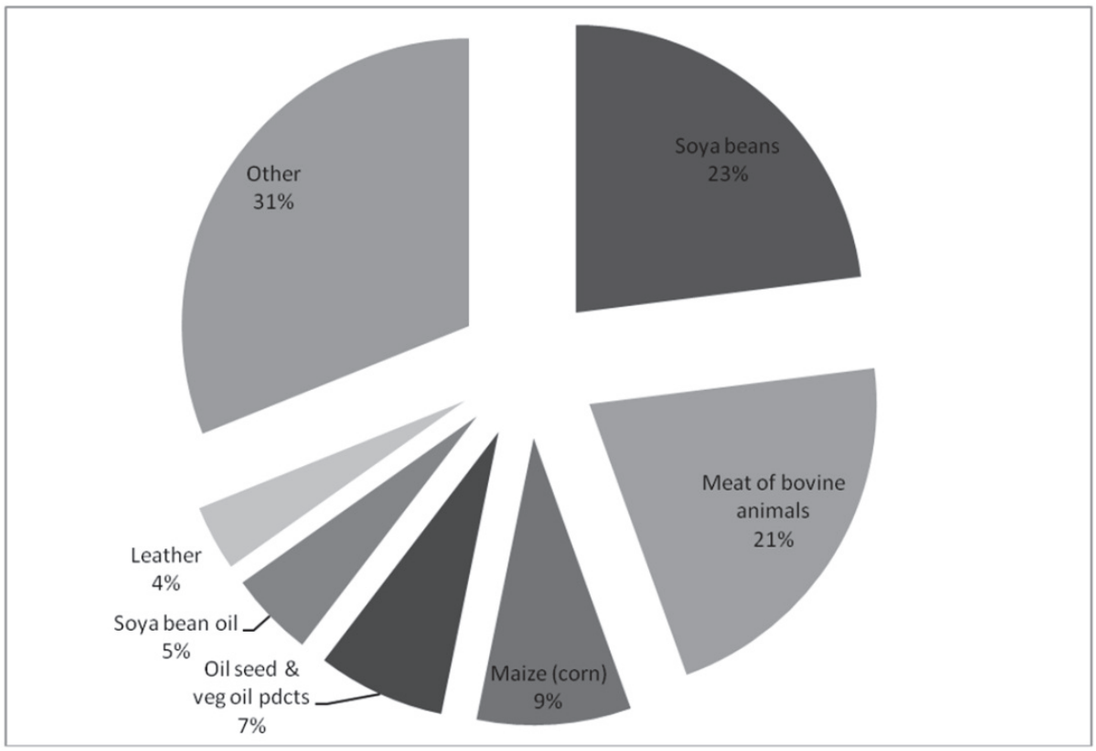

Fig. 3. Source: CEPAL Statistical Yearbook 2008

As seen in Fig. 3, besides cattle raising, which is also linked to deforestation and requires large economies of scale, maize, wheat, cassava, cotton, hen eggs, and sesame seeds are, in

order of size, the other major crops grown in Paraguay. While these certainly could be useful as sources of food for smallholders, they also offer more limited value added linkages and must compete with a considerably larger pool of worldwide competitors, including heavily subsidized agricultural farmers in the North. According to FAOstat, the average farm size in Paraguay's oriental region is only 38 ha. The FAO's report on Paraguay reinforces the aforementioned USDA statistics, "Farms between 1 and 20 hectares own less than 15 percent of the livestock and represent more than 70 percent of allproducers/producer families." The initial reaction might be to push food security for small farmers, however, the World Resources Institute's country report on Paraguay estimates only 5% of children in Paraguay are underweight, as opposed to 27% in the world. Therefore, raising incomes, not starvation, is the pressing issue. Sugarcane, in its dual use, provides more income security than other food crops, should Paraguay be able to develop an ethanol system.

Other non-traditional crops, such as soy and stevia, currently have limited industrial linkages. A domestic processing industry would help to create middle class employment for Paraguayans. Stevia also faces keen competition from large agribusinesses in lower cost production areas. For example, Chinese stevia sells for $14 to $33/kg while Brazilian and Paraguayan stevia sells for $140 to $150/kg (Paraguay Vende, 2004, 39).

5. Sugarcane in Paraguay

5.1 Agricultural requirements for sugarcane

Sugarcane grows best in tropical or subtropical climates, where the average temperature ranges from 26-32 degrees Celsius. Sugarcane has a long growing season of 10-12 months. Sugarcane requires large amounts of water, therefore it must be done in areas where there are high rainfall and natural irrigation. Growing and processing 1 kilo of sugar requires 1500 to 2000 litres of water (Friends of the Earth, 2008), or 75-120 cm of rainfall per year. Long days of sunshine are essential for growth, and fairly dry and clear cool nights for ripening (FICCI, 2009).

As with all agriculture, extension and financing are needed to help with capital equipment, and treatments to prevent weeds, insects, and diseases. Also, research and development monies are needed to help with soil fertility and to develop appropriate varieties for local areas.

Harvesting of sugarcane has traditionally been done with heavy manual labour, however, in more recent years, mechanical harvesting is spreading. Manual harvesting involves separating out and burning the tops (leaves) from the sugarcane stalks. Sugarcane shoots then arise from the remaining stems. Harvesting of the same stalks can continue from 2 to 10 times before replanting.

As with any large monocrop cultivation, sugarcane cultivation in Latin America has a history of linkages to labour exploitation and environmental degradation. The large plantations create concentrations of income. There is also the danger of deforestation if sugarcane leads to destruction of rainforests. Working conditions in Brazilian sugarcane have historically been very poor. There are slave-like conditions in some camps. Sugarcane is harvested seasonally, leading to intermittent work and earnings. The burning of sugarcane creates hazards for the workers and is the most labour-intensive part. Also, the development of new croplands has displaced former cattle areas that then move to the

Amazon, leading to deforestation (Friends of the Earth, 2008). However, Brazil has improved conditions. There is a strong adoption of mechanical harvesting, particularly in São Paulo state.

5.2 Current sugarcane production in Paraguay

Sugarcane has been cultivated since 1549 in Paraguay. However, the disruption of the 2 major wars meant that local output could not meet domestic demand until mid-20th century. For most of its history, sugarcane has been grown on small scale plots with basic technologies (Hanratty and Meditz, 1988, 119-120).

Paraguay is the world's largest exporter of organic sugar. The crop for 2008/9 covers 100,000 hectares and official estimates put the potential at 450,000 tons. Sugarcane is produced in 14/17 departments, but most production is concentrated in the central part of the eastern region (USDA 2008). While organic sugar is another promising market, it does not offer the fuel savings or value added advantages that an ethanol industry does, but again flexibility to adjust to market signals is the key.

Though absolute numbers are relatively small, there are positive signs that sugarcane production can increase; indeed there is a strongly positive trajectory to production over the last 4 decades as shown in Fig. 4.

Paraguay Sugarcane Harvest: Annual Average, 1961-2007

Fig. 4. Source: CEPAL Statistical Yearbook 2008

Interviews with a structured sample of agricultural producers, government officials, and ethanol distillers in Paraguay are uniformly positive that the amount of land for sugarcane

can be increased, though it might mean changing the crop use pattern of some land, primarily small subsistence-based farming. Because sugar is seasonal, an appropriate crop rotation would be needed. Some ethanol production is based on small family plots, thus family members and not an itinerant labour force are responsible for harvesting. Around 29,000 farmers, many small (< 10 ha), are involved, but larger producers are predominantly responsible for most of the sugar produced. About 35% of the sugarcane cultivation is mechanized, with most machinery owned by the farmers themselves (IICA, 2007, 5-6).

According to extensive field research by Benitez, smallholders in Paraguay are currently producing around 50-60 tons/hectare, while Brazilian and Argentine competitors are closer to 120. Part of the problem is the need to introduce new, more productive varieties of sugarcane; he suggests that the Tucuman or RB varieties would vastly increase yields. Lack of equipment (and capital for it) and research and extension to improve local practices are other problems. These point to a general problem of lack of human capital. Yields appear to vary considerably across the country.

According to the IICA, the estimated cost of sugarcane in Paraguay is $13.7/ton (IICA, 2007, 17). This would put Paraguay behind Brazil, but in favourable position in terms of world markets, as demonstrated in Table 1.

Sugarcane production costs internationally, 2006-2007

Country	$/ton
Brazil	10.45
Paraguay	13.7
Caribbean	15
China	23
India	15
Mexico	29
USA	29

Table 1. Source: Hira forthcoming b.

5.3 Conclusion of agricultural analysis

Paraguay faces a series of dilemmas in regard to ethanol expansion that other small countries will face as well. It lacks the financing and extension services of Brazil, reducing its competitive potential. Smallholders in particular struggle with lack of access to finance and insecure property rights. It could support further production through expanding sugarcane into larger fields that would allow for economies of scale and possible approaching of competitive pricing with Brazil. It could mechanize the harvest to avoid replicating the problematic conditions of Brazil's northeastern sugarcane producers. However, this would mean yet another concentration of agricultural production, following the example of soy and cattle, with limited social benefits and possible the loss of the few smallholder sugar farmers.

Based on our own survey and the suggestions of interviewees, there are 2 other possibilities worth considering. The first is one already in motion, and is a response to changes in the European Union towards requiring sustainable certification for all ethanol imports. Paraguay seems well poised to develop its production around this requirement and thus

differentiate its product from Brazil's. A second possibility would be to try to develop the sector around cooperatives that would grow sugarcane separately and share ownership of a micro-distillery. There is some discussion, yet to be confirmed, of new technology being developed in Brazil, that would allow such small scale distillation to be competitive. If so, it could be an ideal way to develop a large part of the new sector in a sustainable way. We discuss further the challenges for a co-op-based system in the governance section below.

6. Industry requirements for sugarcane ethanol

Paraguay is still a predominantly agricultural country, though there has been some growth of maquila assembly, mainly near Ciudad del Este. Unfortunately, the key advantage of extremely cheap electricity so far has not been realized due to a lack of transmission lines from the Itaipu dam to Paraguay. In 2009, an historic agreement was reached to increase the amount of revenues received from Itaipu, to allow for the possibility of selling Paraguay's share to the private Brazilian market (rather than the previous case where it had to sell to Eletrobrás, the Brazilian state owned company), and a possibility to sell to third parties, to be further negotiated. The new revenues could be an important source of reinvestment into infrastructure and industrial promotion for targeted sectors, including ethanol.

Ethanol is produced from molasses derived from sugarcane. Yeasts are added to induce fermentation, producing alcohol. After distillation, further dehydration (removing water) takes place through chemical means. One hectare of sugarcane yields approximately 4000 liters of ethanol per year. Some alcohol is shipped directly for export in dehydrated form, as it may cut costs for shipping (eg by reducing the possibility of contamination) and may face different import barriers.

The dehydrated ethanol is denatured (purified) and moved to gasoline wholesalers/distributors, where it is blended. The blended gasoline is then shipped to retail outlets. In Paraguay, most ethanol is sent by tanker trucks from distributors to retail outlets. While pipeline transportation is possible, ethanol is corrosive and takes on water, requiring high quality and frequent inspection of materials (BNDES and CGEE 2008, 60).

We can describe the overall process of ethanol refining as occurring in two overall stages, agricultural and industrial, with finance, labour and land costs and quality, quality and costs of capital equipment, quality and costs of sugarcane and petroleum and their substitutes; costs of imports (both inputs and petroleum) and transportation costs pervading all of them.

In Paraguay, Petropar, the state oil company, by regulation, has a dominant position in wholesale distribution, covering 80% of gasoline in the country. Petrobrás, the Brazilian

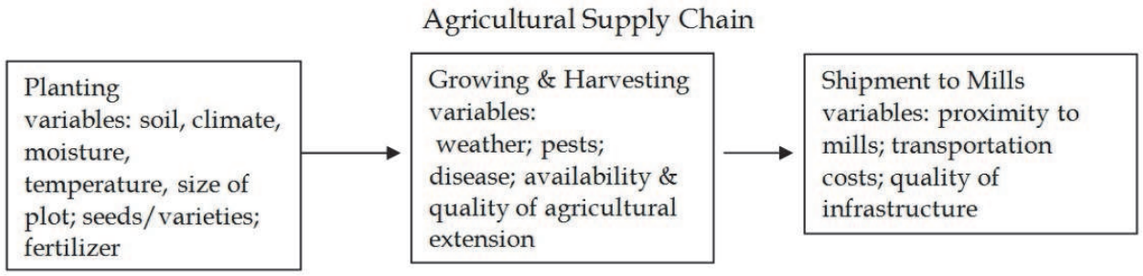

Fig. 5.

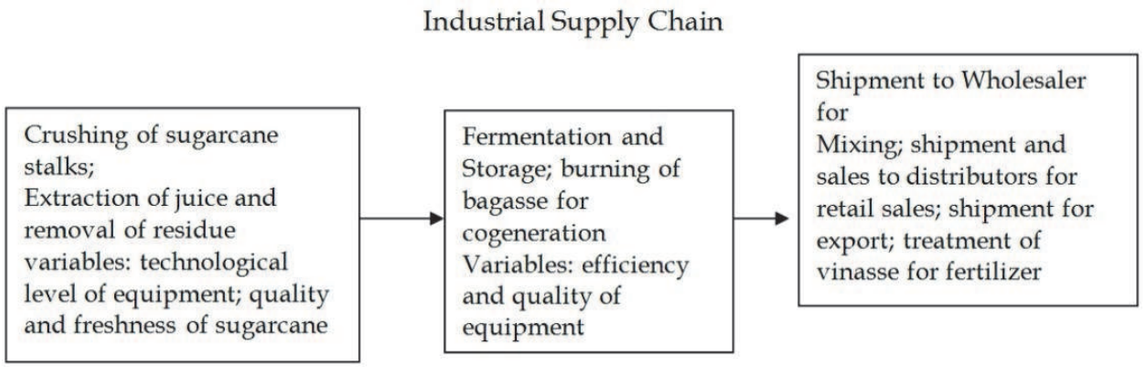

Fig. 6.

giant with state ties, is an exception in distributing its own fuel to its many retail stations, but it does not carry ethanol yet in Paraguay.

6.1 Transport requirements

Transportation infrastructure is vital yet underdeveloped in Paraguay. Eighty five percent of all domestic and international goods is transported by roads. Agro-industry and rural development are thus intimately linked with and constrained by transport costs. Import and export costs tend to be the highest in the region. While Paraguay has 0.77 km of paved roads/1000 inhabitants, Argentina has 3, and Uruguay 4. As a result of these problems and its landlocked status, Paraguay's transportation costs for trade are 43% higher than the average cost for South American economies. Road maintenance is poor, with 30% reported in bad condition in 2006, and several communities lacking all weather access. There are problems with transportation and planning in government, including inadequate information systems and monitoring (World Bank, 2006, 2-4; CEPAL, 2003).

Another key challenge is the fact that 70.4% of all cars are diesel, while only 21.3% run on gasoline (Roundtable 2008, no.1). Ethanol under current technology mixes only with gasoline. Therefore, Paraguay will have to completely revamp its vehicle fleet towards flex fuel vehicles in order to develop a viable domestic market. The Government is well aware of this challenge and has begun to change incentives through tax and tariff regulations to promote a shift in the vehicle structure.

6.2 Current state of Paraguayan ethanol industry

Of an estimated 2,280,000 tons of sugarcane produced in 2006, the Centro Azucarero Paraguayo estimates that 1.4 million were processed into sugar, 760,000 into alcohol, and 120,000 into honey, as demonstrated in Fig. 7 below (IICA, 2007, 8).

Sources of data on biofuels are quite limited. The Biofuels Roundtable, organized by REDIEX of the Ministry of Industry and Commerce, has produced the only reports known to us with data. Their first report from 2009 notes that current capacity in Paraguay is at 236 m (million) litres of ethanol per year, well beyond their estimates for demand at 95 m litres. All plants are producing under capacity, with utilization rates ranging from 20-85%. They note major limitations in regard to the availability of sugarcane, something we also noted in

field research. Three companies, Petropar, INPASA (Industria Paraguaya de Alcoholes S.A.), and AZPA (Azucarera Paraguaya S.A), produced 60% of the ethanol in the country in 2009.
Benitez (2007) notes that Paraguayan distillation is inefficient because of backwards technology, so that transfer of Brazilian technology is necessary. An example of this became clear during author site visits to the distillation plants of INPASA, which was using state of the art Brazilian equipment, while that of Petropar seemed considerably less efficient.

Uses of sugarcane in Paraguay, 2006

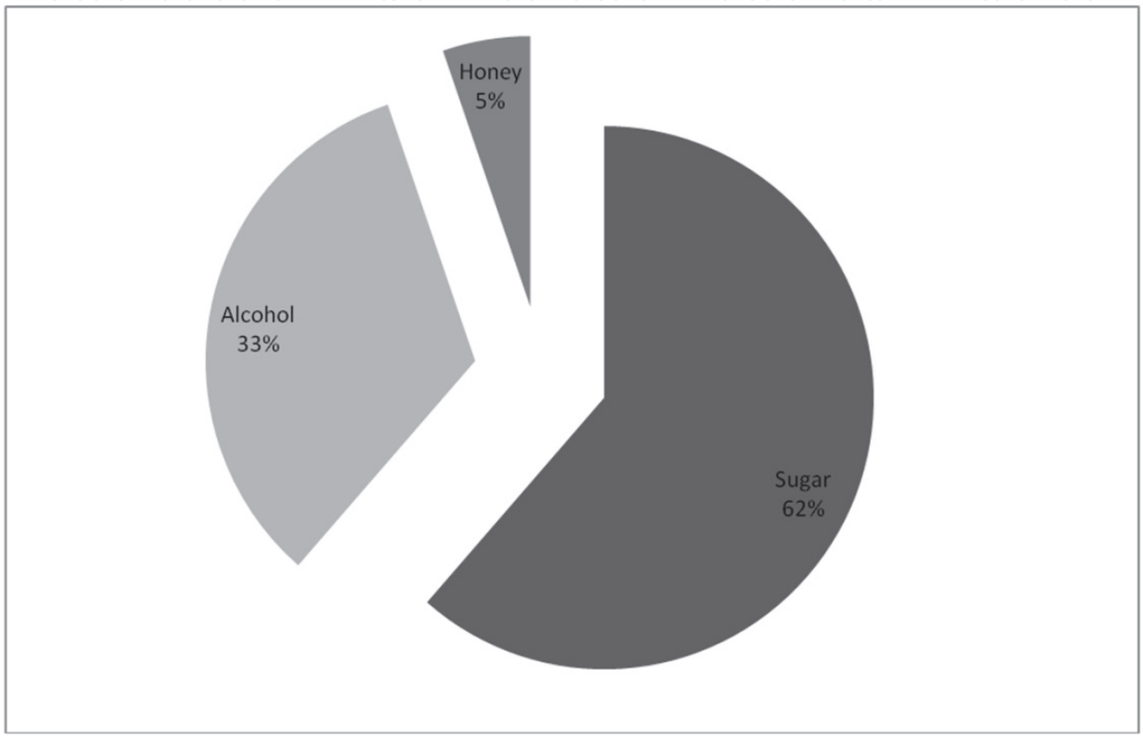

Fig. 7. Source: IICA 2007, 8

The changes in governance framework for ethanol (see below) appear to be paying off, as 2008 saw an increased production to 90 m litres of ethanol, almost all from sugarcane. Production for 2009 is forecast at 120 m litres, with projections continuing to increase afterwards. There are 8 sugar mills in Paraguay, two of which have anhydrous ethanol distilleries, and two that produce hydrated ethanol. There is also one plant that can produce ethanol from corn, manioc and sorghum (INPASA). The largest producer with estimates ranging from 26-40% is Petropar, the national oil company. Official estimates suggest that Paraguay could export up to 300 m litres of ethanol by 2013. However, currently (2009) there are neither exports nor imports (USDA, 2008 and IICA, 2007, 12). Current cost estimates for dehydrated alcohol are $.46/litre and for hydrated .41/litre (IICA, 2007, 17), however costs do seem to vary considerably from plant to plant and evidently by feedstock and other input costs.
One vital fact is to reinforce is the current cost differences with Brazil. Table 2 summarizes the differences as estimated by an ethanol engineer in Paraguay.

Item	Paraguay	Brazil	Differential
Sugarcane	**45 tons/hectare**	**100 tons/hectare**	**122%**
	$20/ton	**$16/ton**	**25%**
costs of harvesting	**$5-6/ton**	**$3-4/ton**	**67%**
time to factory after milling	**120-170 hours**	**48-72 hours**	**150%**
transport costs	**$6-8/ton**	**$3-4/ton**	**100%**
refined sugar	**$430/ton**	**$275/ton**	**56%**

Table 2. Source: ethanol engineer in Paraguay (anonymized)

Our source (anonymized engineer) tells us that the end result is that distilled ethanol is 20% less efficient in Paraguay than Brazil, due to lower sugar content, higher rates of infection, and outdated machinery. Paraguay still relies on small producers who have not achieved minimum economies of scale, likely at 50 hectares. However, the solution is not as simple as reproducing the Brazilian model as we discuss below.

6.3 Conclusion

Field research revealed a universal problem of lack of access to finance in Paraguay that undoubtedly impedes all sectors in the economy, and will be particularly problematic for paying for the up front costs of new equipment.

On the other hand, the development of a strong industrial base for ethanol in Paraguay seems less problematic than for the development of a competitive agricultural one. Brazilian state of the art technology is readily available, and through Petropar and Paraguay's strong tradition based on dam construction there is a ready supply of engineers. As we have seen, the transportation sector is problematic in terms of the poor state of secondary roads, needed for gathering agricultural materials and getting them efficiently to the plant. It is not only a question of costs in terms of time lost, but also that fresh agricultural goods yield higher levels of ethanol. The lack of organization and public support for the agricultural part of the chain have led to some distillation plants beginning to initiate their own efforts at agricultural production, which could be an efficient solution, but one perhaps with considerably less social benefits.

One dilemma in developing the industrial chain relates to the role of Petropar. Petropar was created in 1985 as an autonomous company, with operations beginning the following year. In Brazil, the dominant state oil company Petrobrás was key to stabilizing the ethanol market through its decided policy to create a large market for ethanol, including cross-subsidization during price swings, and its ability to vertically capture the production chain, ensuring retail availability (Hira and de Oliveira, 2009). In Paraguay, the industrial structure of the energy sector is considerably less propitious. Indeed, a 2006 World Bank report found that there was no real energy policy in Paraguay; that Petropar lacked any objective financial transparency or oversight; that Petropar was handicapped by state policies to subsidize diesel, which made it cheaper than gas; and there generally was no oversight into quality standards in gasoline. It suggested ending price fixing and subsidies, setting up an independent regulator, and allowing Petropar to compete as a separate entity with other

private companies. The suggested reforms have been discussed but the legislation has not yet passed.

While Petropar as the key wholesaler is the main blender for ethanol, not all gas is mixed (despite regulations noted below). There are a wider variety of companies involved in the sector, including some fairly small independent stations, that are quite reluctant to take on the costs of new infrastructure that would afford a wide variety of blends (%s of alcohol with gas). Having a variety of blends was essential for instilling confidence in Brazilian consumers that they would have the flexibility to deal with price drops in petroleum. To reduce costs, it would make sense to simplify the number of blends from potentially 5 to possibly 3 for most stations. Petropar could then have an advantage in offering a wider variety of blends at its stations.

However, Petropar is currently in heavy external debt related to an agreement with Pedevesa, the Venezuelan state oil company, regarding contracts that did not reflect the drop in oil prices over the last year. Petropar's red ink led to the sale of Paraguay's only refinery and a continuing debt. We think that Petropar should be relieved of its wholesale distribution position, and be allowed to compete head on with other oil companies. The government could follow the example of Petrobras and give Petropar the lead in oil exploration in the country, as well as autonomy in its accounts, but in return it would require the need to move to transparency and competition at all levels. Petropar could thus begin to capture market share at the retail level, where it is quite limited, improving its options.

7. Governance requirements for an ethanol industry

7.1 General context

There are a limited number of studies of Paraguayan governance. One of the more recent is an Inter-American Development Bank-sponsored report by Molinas et. al. The report takes a comprehensive view of the Paraguayan policymaking process. It finds a strong level of "rigidity" in the process that is effective in delivering "particularistic" benefits, but not redistributive or regulatory reform. The system is a result of the combination of heavy repression and patronage under a one party system during the *stronato* (Stroessner's rule), marking a hyperexecutive system (one dominated by the executive branch). The Paraguayan case is considered a "triumvirate" of the military, the Colorado Party, and the government. During this period, the high levels of the bureaucracy were filled on the basis of loyalty, meaning that there was little turnover in terms of personnel or ideas. Public employment is the principle instrument of cooptation; public sector workers earn an estimated 17X higher wage than private sector counterparts (vs. an average of 4% for the rest of Latin America) (Molinas et. al., 2006, 10 & 43). Nonetheless, economic growth during the late 1960-70s was high, based on the development of agro-exports and dam construction. The government followed a deliberate long-term strategy of developing agricultural lands on the Eastern border with Brazil in order to reduce dependence on Argentina (Molinas et. al., 2006, 12).

There are major institutional challenges for the Paraguayan public sector, according to an article by Nickson and Lambert (2002). They note that Paraguay is ranked as one of the most corrupt countries by Transparency International. Moreover, there is a low tax base, meaning a paucity of resources, a lack of a merit-based civil service, a lack of evaluation-oriented

units, and a high level of politicization. They cite the general ineffectiveness of the neoliberal reforms after 1989 focused on civil service reform, privatization and decentralization. A World Bank report (2005, ix.) notes similar problems, citing in particular the human resourcing system for the civil service; a lack of inter-institutional coordination, and of participation by citizens; poorly qualified public employees with little in service training; inconsistency in salary levels according to classification; high rotation of senior and middle management; clientelism, including promotion based solely on political and personal loyalty; lack of transparency in recruitment; and no performance evaluation measures. While a new law attempting to address some of these problems was instituted in 2001, many of the new features were suspended "within weeks" (World Bank, 2005, 170).

Nickson and Lambert suggest serious problems with the process of privatization. They suggest that buyers were closely tied to the elite and contracts were corrupt and undervalued. The state alcohol plant, APAL, was converted into a company, Cañas Paraguayas (CAPASA), in 1993, and privatized in 1995. The key purchasing company, Tekojaja SA, only paid 1/5 of the agreed price for majority share ownership, leading to the state retaking control in 1997. The company was operating at a loss at least through the time of the writing of that article in 2002. In mid-2001, the government's state reform secretariat (Secretaría Nacional de Reforma del Estado, SNRE), asked for the company, then with $1.5 million in debts, to be declared bankrupt.

The decentralization law sought to pass more control over finances to provincial and local authorities, in line with the new public management ideas in vogue in the 1990s. While a new law granting shares of royalties from the two binational dams was passed in 1998, the actual transfer of resources has not been properly implemented, and only a fraction of promised resources have been transferred. In fact, with Itaipu and Yacyreta producing a large share of total national revenues, the lack of transparency concerning both revenues and expenditures is a major obstacle to any kind of accountable budget. Such revenues could be a key source of resources for industrial policy, however at this time it is impossible to say with any clarity how revenues are being used. Besides this black hole, there is another problematic aspect to government budgeting. The controlaría nacional (national accounting office) is manned by the opposite party of that in power. While attractive at first glance, it would be more logical and consistent to have an autonomous body à la the Central Bank to produce audits and accountability in government accounts.

7.2 Current policies towards ethanol

The government has taken the logical first steps to support the industry. Paraguay has had formal provisions for blending since Decree 2162 of March 1999 that set up a 7% ethanol blend. In Oct. 2005, the Paraguayan Congress passed Law 2748 for Biofuels Promotion. The law declares biofuels to be a national interest. It sets blending for ethanol at a range of 20-24% gasoline. Biofuel use is mandatory as long as there is sufficient local supply. It encourages the use of different local feedstocks. It provides tax benefits, especially concerning investment. The Ministry of Industry controls investment and determines production levels, and that of Agriculture and Livestock certifies feedstock. In May 2008, the government passed Decree 12240 reducing the VAT on biodiesel and ethanol to 2% and eliminating import duties on flex fuel and E85 new and used cars. Ethanol imports are banned, though a special exception was given to Brazil in 2008 for 6 million litres (USDA, 2008; Souto, 2008, 46).

The government has lofty goals in regards to future exports. The Roundtable for Biofuels' National Plan for Biofuels envisions significant increases in both ethanol and biodiesel production for replacing 50% of local demand for petroleum and exports. It includes goals for employment, savings of import expenses, attraction of new investment, and environmental improvement.

There is also discussion of government support through its own procurement policies. Paraguay will need regulation that deals explicitly with ethanol in terms of fuel standards in order to prepare for possible exports. It will have to consider whether it wanted price supports, particularly in terms of stabilizing the price. It should also consider labour legislation. Lastly it needs explicit regulation in regard to investment in the sector. A neutral regulator will have to be set up to govern the sector. While there seems to be a general awareness of these regulatory requirements, legislation and the needed resources seem to be slow in coming, reflecting the fragility of the governing coalition. Moreover, field research interviewees raised a number of doubts about the extent of de facto enforcement of existing provisions. These reflect back on even more serious challenges beyond the general ones of corruption, lack of resources, and low levels of technical expertise that impede governance in all areas. It was difficult to tell through field research the exact number of stations that carry ethanol; we heard different answers to the question from different experts. We did on visual observation notice availability in some stations in Asunción.[1]

7.3 Lack of long-term vision and planning

Field research interviewees repeatedly noted the lack of a shared long-term vision for the country, though some individual offices were attempting to develop one. This is a problematic aspect, as the development of any new sector requires not only coordination but determination among multiple actors to get through the high costs and learning curve of setting up a new industry. Some interviewees suggested a vision that takes advantage of Paraguay's location to create infrastructure so that it could be used as a shipping point. They cite plans for developing railway lines to Brazilian ports and better roads and ports, as well as possibly gas pipelines from Bolivia to the markets of Argentina and Brazil. During field research there was also the exciting prospect discussed of selling surplus electricity to Chile via Argentina. This would also require major investment in transmission lines as well as clarification of the dam agreements.

The Brazilian case signals the need to have clear, long-term goal posts for the program during which progress on reducing costs can be made. The goals would be set up by the stakeholders. Brazil also set up key support policies along the following lines: Petrobrás, the oil company, guaranteed a minimal purchase each year, low interest loans were given to help set up ethanol distilleries through the Bank of Brazil, final prices were subsidised and smoothed out through the tax system on fuels and vehicles, to ensure competitiveness with gasoline, and production quotas for sugar production were set. One of the main stumbling blocks experienced in Brazil was that sugar production was initially inadequate to meet rising demand, so lag times should be a major consideration (Hira and de Oliveira, 2009).

[1] While biodiesel was not the subject of this study, we did find it curious that the government has promoted a processing plant using animal fat. This is not only out of step with international research on the efficiency of different feedstocks but also inherently limited in terms of total supply. Moreover, there is concern by those in the industry that animal fat leaves damaging residues in engines at temperatures below 15° C.

7.4 Coordination breakdowns

Field research revealed a gap in inter-institutional coordination among different government ministries and the private sector. There seems to be a lack of recognition of the inter-sectoral nature of ethanol, spanning across agriculture, industry, energy, and transportation. One source for hope is the recent development of the Mesa Rodonda de Biocombustibles (Biofuels Roundtable) that brings together private partners and the Ministry of Industry and Commerce.

Within the agricultural sector itself, there are severe governance problems. A 2004 USAID report notes: a total lack of clear medium- and long-term policies towards land distribution; a lack of coordination between the Min. of Agriculture and Livestock (MAG) and the Rural Development and Land Institute (INDERT), two actors key to the sector; the fact that census and survey data are extremely dated, with the last National Census taking place in 1991; and a lack of agreement between soy producers and the government in regard to the level of taxation for that product. Besides MAG and INDERT, the National Survey Service (SNC), the General Public Registry Directorate (DGRP) and the municipal governments are the other key public sector stakeholders. However, interviewees noted that MAG was largely out of the loop in terms of current developments on ethanol. The Ministry of Industry and Commerce (MIC) seems to be taking the lead without working with MAG. This means a series of potential problems with improving sugarcane yields and quality for industry growth.

Based on the example of Brazil, a multiple stakeholder approach would be needed, with partners from the private, non-profit, and public sectors all working together. The private sector partners would include farmers, agricultural supply companies, transport companies, and others who are part of the production process. The non-profit partners would include industry associations and non-governmental associations that represent environmental and labour rights interests, as well as civic associations where the industry takes hold. The public sector would require agricultural, treasury, transportation, and pro-export components. Coordination of these ministries is key. Finally, there would be a need for a research and development component to improve production costs, introduce innovation, and monitor the program according to local conditions. In the Brazilian case, public sector partners were brought together under Proálcool, a national program with explicit goals of reducing petroleum dependency through substitution for ethanol.

7.5 The Brazilian road not taken

Perhaps the more sensible direction from the point of view of feasibility as alluded to above would be at least initially to encourage Brazilian ethanol companies to invest in Paraguay for export production. This would require a stable regulatory climate and encouragement of investment. It would give time for technology transfer to take place and a ready export market while Paraguay developed the agricultural, industry, and policy requirements for domestic consumption and the knowhow and financing for exporting. A variant on this option, not mutually exclusive, would be to woo other investors, such as Japanese companies, or large multinationals such as Louis Dreyfus, that are active in Brazil. This would alleviate Brazilian concerns about quality control and facilitate customs processing.

There are signs of Brazilian interest. At the end of 2006, MERCOSUR set up a Special Working Group on Biofuels. In 2007, they identified an action plan, including evaluation of different feedstocks and production capacity; identification of research entities for

partnerships, analysis of the infrastructure and distribution systems for fuels, and tools to promote investment in biofuels. In 2008, the MERCOSUR countries signed an MOU (Memorandum of Understanding) to develop a program of cooperation for biofuels. In 2007, the Presidents of Brazil and Paraguay signed an MOU (Memorandum of Understanding) on Biofuels. This set up cooperation in evaluation of different feedstocks' potential; technological development in the industry; analysis of infrastructure and transportation system needs; and investment in Paraguay. Paraguay is working with Embrapa (Brazilian agricultural research and extension agency) on this task (USDA, 2008).

However, it seems quite unlikely that a full embrace of Brazilian investors will ever take place. Based on a history of Brazilian domination, Paraguayans are understandably reluctant to base a promising new industry on strong levels of external dependency. Benitez's vision for the sector seems to reflect that of many in Paraguay, that the Brazilian road will not lead to employment or national value added effects. Hence he calls for "1000 micro distilleries producing 1 million litres of ethanol" through intense coordination of small farmers, the public sector, and private middlemen.

The possibility of capturing value added for local employment is a pressing concern and also reinforces the general notion and political fact that biofuels is seen in light of a more nationally-oriented development. The general desire for national development is further reinforced by the political fallout of the multinational-led growth in agribusiness in Paraguay, leading to large-scale consolidation of lands, and ubiquitous protests by those who want land reform, with soy being a particular target. We are not in a position to gauge the merits of such debates, though capitalization of agriculture and displacement have been universal developments. However, this brings us back to the problem of the lack of competitiveness of Paraguayan producers with Brazilian counterparts, meaning in the long-run a likely unsustainable situation of domestic protection and inability to realize exports. Indeed, during field research the smuggling in of cheaper ethanol from Argentina and Brazil was revealed as a source of concern for the government.

7.6 Sustainability certification and co-ops

One way around this situation suggested by an interviewee was to market Paraguayan production internationally as sustainable. The interviewee revealed that promising discussions were underway with the European Union for certifying Paraguayan production. This would give Paraguay the possibility to differentiate its product from Brazil. It seems plausible in the sense that the EU not only needs to import to meet its own biofuel targets, but in that Paraguay's production would not overwhelm its own producers as would Brazil's.[2]

However, there have been several major problems with this laudable idea. The first is that certification does not provide the resources to monitor and violations are rarely enforced. The second is that certification systems are not set up for local input (Friends of the Earth 2008). Brazil has already moved in this direction, thus could provide tech transfer, but this also means the potential dissipation of advantage based on differentiation.

Moreover, as noted above, Paraguay would clearly need institutional reform. It could set up local stakeholder councils that included growers, large consumers, public officials, workers,

[2] The US and EU markets remain protectionist limiting the potential international market for ethanol, though there are discussions about ways to open it up. For more information, see Hira forthcoming,

and local communities. These would begin to develop best practice standards in conjunction with attempting to follow certification standards as laid out in a number of European-based proposals. These are costly proposals and would require considerable up front investment. Paraguay would need assistance from the EU in financial and technical terms, as well as long-term contracts, to seriously consider such a move.

Another intriguing idea presented itself from field research. In Paraguay, there is a long history of very successful agribusinesses based on co-operatives. Some co-operatives have become dominant in areas such as dairy products, even achieving the ability to export. Co-ops by their nature are egalitarian with family farmers sharing capital goods such as tractors and helping each other through the frequent swings of agricultural markets and conditions. They would seem to be an ideal vehicle for avoiding the large concentrations of land and production in much of the modern sectors of Paraguayan agriculture, while still offering a vehicle for achieving Brazilian style economies of scale and possibly even co-op distilleries and transportation networks. Many Paraguayan co-ops have their own financial organizations. Some have even begun pilot projects to produce sugarcane.

However, there are severe obstacles to this solution as well. Most of the successful co-ops in Paraguay in terms of exports are religiously-affiliated communities of highly educated European and North American immigrants. The homogeneity of such communities does not lend itself to easy transfer to the landless and poorly educated groups of Paraguayans displaced from the growth of agribusiness. Interviewees familiar with co-ops in Paraguay suggested that it would be unlikely for existing co-ops to fully invest in the sector unless there was more stable and consistent support from the government to support the industry over the long-run. Still, it is interesting to note that the first major biofuels seminar organized by the Paraguayan government (Sintesis, 2007, 42) contains a conclusion with this very suggestion- that co-ops would be the way to preserve small farmers in the market.

8. Conclusion

While daunting, the problems for creating an ethanol sector in Paraguay are not insurmountable. Agricultural and industry requirements call for a true government commitment to the sector. Thus far, a full acceptance of ethanol as a target industry does not seem to be in the minds of Paraguay's leaders. Governance requirements are more mine-ridden, reflecting problems throughout Paraguay's economy. A program of training and reform in the state sector is direly needed. The possibilities for sustainable certification and some portion of co-op production are two very intriguing avenues for further exploration. However, the first and most important step remains the lack of a clear understanding for a long-term vision and plan for Paraguayan development and industrial policy. Most interviewees seemed sceptical about the prospects for an active industrial policy and wanted to see instead a "level playing field," with the state acting as a stabilizing force for the market. We are doubtful that such an approach would suffice to create a brand new industry, however we do understand the general reservations based on the historical weakness and current problems of the Paraguayan state. Our report shows, in sum, that a viable ethanol industry is feasible only if Paraguay is able to close the gap in terms of cost efficiencies with Brazil, and that it might do so in a way that is considerably more socially advantageous than Brazil, but it will require a strong and flexible state policy to achieve these goals. Our article also provides a precautionary note to other would be states about the very real challenges to developing a viable biofuels sector.

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10. References

Interviews*

We include here the names of key interviewees during field research by Anil Hira and Plinio Torres. All interviews were conducted by Hira in July 2009 in Asunción, Paraguay. By prior agreement, we have anonymized any particular citations in this document to protect our interviewees. We gratefully acknowledge the willingness of participants to meet with us and their frankness, and particularly their generosity in time and in setting up site visits. We also conducted 3 site visits, to 2 alcohol distilleries and to Friesland cooperative.

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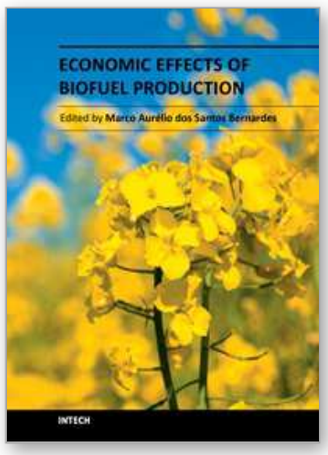

Economic Effects of Biofuel Production

Edited by Dr. Marco Aurelio Dos Santos Bernardes

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This book aspires to be a comprehensive summary of current biofuels issues and thereby contribute to the understanding of this important topic. Readers will find themes including biofuels development efforts, their implications for the food industry, current and future biofuels crops, the successful Brazilian ethanol program, insights of the first, second, third and fourth biofuel generations, advanced biofuel production techniques, related waste treatment, emissions and environmental impacts, water consumption, produced allergens and toxins. Additionally, the biofuel policy discussion is expected to be continuing in the foreseeable future and the reading of the biofuels features dealt with in this book, are recommended for anyone interested in understanding this diverse and developing theme.

How to reference

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